How can current slaughter and dressing procedures in UK pig slaughterhouses be improved to reduce contamination of pig meat with pathogenic bacteria?

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Abstract

In pork slaughterhouses a number of dressing stages have the potential to improve the hygienic condition of the carcass surface. The operations performed at each of these dressing stages can be undertaken using a diverse range of mechanized systems that each have different reductive effects on the levels of microbial contamination. Our results show that pre-washing optimizes the effectiveness of condensation scalding in improving carcass hygiene, and that the same areas of carcasses are consistently not effectively heated by singeing/flaming, independent of the different systems used in pork and bacon slaughterhouses.

Introduction

Salmonellosis is one of the most frequently reported gastrointestinal illnesses of the European Union (EU) and consumption of contaminated pork meat is recognised as one of the key sources of the disease in humans (Fosse *et al.*, 2008). Great efforts have been made to reduce the prevalence of *Salmonella* in the EU pig herd. It has been established that, once on-farm controls to reduce the incidence of *Salmonella* in pigs have been introduced, it becomes increasingly economically advantageous to focus efforts to reduce the prevalence of *Salmonella* at the slaughterhouse (Alban and Stärk, 2005). It is recognized that carcass dressing stages that involve heating or drying of the carcass surface, such as scalding and singeing, reduce the levels of microbial contamination (Borch *et al.*, 1996; Pearce *et al.*, 2004). However, a number of different approaches may be employed to each stage of carcass dressing using a range of apparatus of differing designs with different operating parameters. Therefore, apparently similar operations performed at different slaughterhouses may have dissimilar outcomes. Following a base-line study of four slaughterhouses (Richards *et al.*, 2007), our study has focussed on thermal processing stages (scalding and singeing) where time-temperature parameters vary.

Material and Methods

Slaughterhouse Selection
Following an assessment survey of the processes and operating conditions of the UK pork slaughter industry, representative large UK slaughterhouses were selected for study (Richards *et al.*, 2007) as between them they performed the range of common slaughter and dressing operations identified in the UK industry. Subsequently, individual stages associated with particular slaughterhouses were examined in detail.

Thermographic Methods
The thermal imaging camera used at the pork slaughterhouses was a Flir ThermaCAM PM695 PAL (FLIR Systems Ltd. (UK), Kent, UK.), while that used at the bacon plant was a Flir E320 (FLIR Systems Ltd. (UK)). Thermal images were taken about 1.5s after exiting the singer and care was taken to ensure that the carcasses avoided being rinsed prior to imaging. Emissivity was taken as 0.95.

Assessment of Carcass Hygiene

Carcasses were sampled following key stages of processing, with non-sequential carcasses evaluated at each stage. Whole carcasses were sampled by sponge-swabbing following the Food Standards Agency (UK) guidelines (Anon, 2006). At slaughterhouses practicing condensation scalding, samples were taken after bleeding, after scalding and pre-chill over two visits. To assess the effect of singeing on microbial contamination, sponge-swab samples were taken from three sites (belly, trotter, anus) identified as 'hot' and 'cold' spots through thermal imaging. Sponge-swabs were assessed for levels of *Salmonella*, *Escherichia coli*, Enterobacteriaceae and total aerobic bacteria, as appropriate, following standard methods.

Results

Condensation scalding systems were examined in three slaughterhouses. In slaughterhouse A the condensation scalder was fitted with an integral pre-wash system and operated at 63.8°C with a residency time of 4.5 min. Slaughterhouse B ran an older system that operated at 65.8°C for 8 min. Although similar initial total aerobic counts were present on the carcasses prior to scalding ($P > 0.05$, Student's t test), there was a difference of ~1 $\log_{10}$ colony forming units (CFU) cm^{-2} afterwards ($P < 0.001$), with carcasses in slaughterhouse A showing the lower counts. After scalding Enterobacteriaceae numbers were reduced to barely detectable levels and no statistical difference existed between levels of contamination in either slaughterhouse ($P > 0.05$). At Slaughterhouse C, where pre-wash samples were accessible, there was an approximate 10-fold reduction in the total aerobic count following the pre-wash stage, which was not reflected in Enterobacteriaceae or *E. coli* counts. There was no access to post-scald samples; however, this suggests that pre-wash systems are beneficial in reducing the initial contamination.

The efficacy of singeing was examined using a thermal imaging camera to determine surface temperatures of carcasses immediately after singeing in three plants using two models of singer: i) fully enclosed style with a single flame from the base ii) vertical, intermittent gas flame. Thermal images of the carcasses post-singe indicated that the temperature across the carcass was not uniform and detected several consistent 'cool spots' (Figure 1). The temperatures of the flat surfaces of the carcass such as the belly were relatively uniform and temperatures over 80°C were recorded (Figure 1A). The lower trotters (Figure 1B) and areas around the anus and/or scrotal sack (Figure 1C) were colder, with temperatures less than 55°C. Total aerobic counts at the three sites were similar pre-singe but after singeing the belly counts were on average 1-2 $\log_{10}$ CFU cm^{-2} lower than those at the other two sites. After polishing counts were 2-3 $\log_{10}$ CFU cm^{-2} higher and very similar at all three sites, suggesting a redistribution of the bacteria (see Wei *et al.*, 2009). Enterobacteriaceae counts were higher around the anus pre-singe than the other two sites but singeing reduced counts at all three sites to a similar level. Polishing increased the counts at the anus more than at the other two sites. The *E. coli* counts reflected this difference.

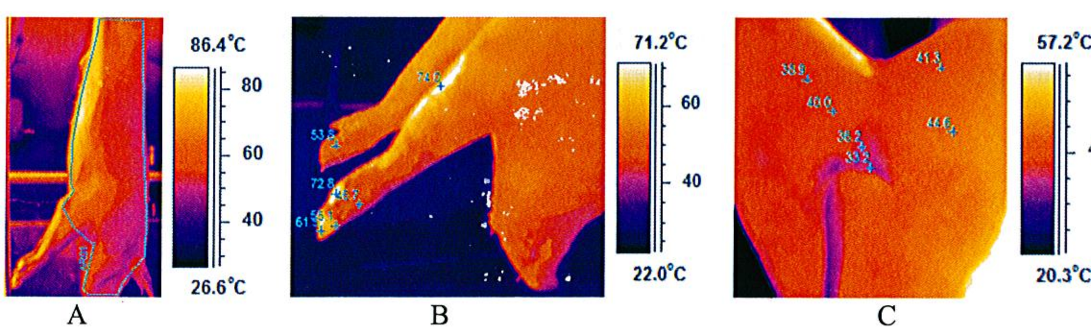

Figure 2. Surface Temperature of Carcasses Immediately Post-singeing

Discussion

Comparison of data from slaughterhouses using condensation scalding with varying parameters showed that the more stringent scald parameters produced a smaller reduction in contamination. This suggested that the control of microbial loads by condensation scalding relied on factors other than time-temperature parameters. The design of the machine may be an important factor: pre-washing did show some impact on reducing bacterial contamination; it may also serve to increase the inimical effect of the hot water vapour on the contaminating microflora by removal gross contamination and making the surface more accessible to the water vapour. Additionally, data from this study suggest that the presence of 'cold' spots in the singe operation does influence the survival of bacteria on the carcass surface and these could act as a seeding source, causing redistribution of contamination by the polishers. Presently, in the UK no producers operate any additional inimical process against bacterial pathogens before chilling. Hence singe efficacy is key in reducing carcass contamination levels.

Conclusion

Our results suggest that process design can have an important impact on thermal operations which go beyond gross time/temperature parameter measurements. Optimization of processes could improve carcass hygiene and bacterial pathogen carriage on pork meat by the adoption of relatively simple changes in practice.

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